SPRAYING PROGRAM FOR THE ORCHARD AND FRUIT GARDEN

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SPRAYING PROGRAM FOR THE ORCHARD AND FRUIT GARDEN

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Changes in spraying procedure become necessary from year to year in the production of Ohio fruits. This is due in part to the ever changing conditions concerning the pests against which the treatments are directed and in part to the development of new sprays and to new information concerning old ones.

Because of the multiplicity of pests, as well as the spraying materials suggested for their control, it is no longer possible to make individual application for each trouble. Spraying materials must be combined so that more than one pest will be controlled by a single application and each application must be made at the time when it will yield the greatest possible protection. Moreover, seasonal variations, orchard cultural practices, and general environmental conditions largely govern the severity of both fungous disease infections and insect infestations. For these reasons it may require a rigid or complete spray program to control pests in some orchards while in others, during the same season, such a program may not be at all necessary. Moreover, the seasonal or environmental conditions govern spray injury, a factor that must be considered in all spraying operations. In fact, in recent seasons the "cure" (spray) has caused more loss in some orchards than could have been expected from the pests.

The present program aims to take all these factors into consideration: first, by pointing out many modifications and short cuts in spraying operations; second, by saving time and materials where possible; third, by reducing foliage and fruit injury to a minimum; fourth, by emphasizing the necessity for thoroness and timeliness of application. That most of the ills in spraying operations can be

overcome by thoroness has been demonstrated by one of us (Ballou), who has completely controlled both scab and blotch with very dilute sprays.

Timeliness in application of sprays is probably the most important factor in disease and insect control. As a rule sprays do not protect over a very long period; because, first, they decompose rapidly and, second, new, unprotected growth is continuously being formed. Since it is impossible to keep a complete protective coat on foliage and fruit, it is important to time the application for the infection periods.

It should always be remembered that spraying procedure in the main is a preventive measure and not a curative one. Whether the pest be an insect or a fungous disease, our whole efforts in spraying are directed toward preventing its becoming established on the host. There are a few exceptions to this rule as, for example, in scale control, where we spray to rid the host of the pest after it has become established.

It is because of this general principle, that timeliness in spraying is an item of paramount importance. We must anticipate the pest and have our insecticide or fungicide standing guard when the fungus or insect enemy appears.

An attempt will also be made to point out the comparative value of spray materials. What to use, is a frequent question among fruit growers and is becoming increasingly difficult to answer owing to the large number of commercial materials now on the market. While we continue to recommend the old standard sprays, an attempt will be made to point out the merit of patented proprietary materials and when and where they may be substituted.

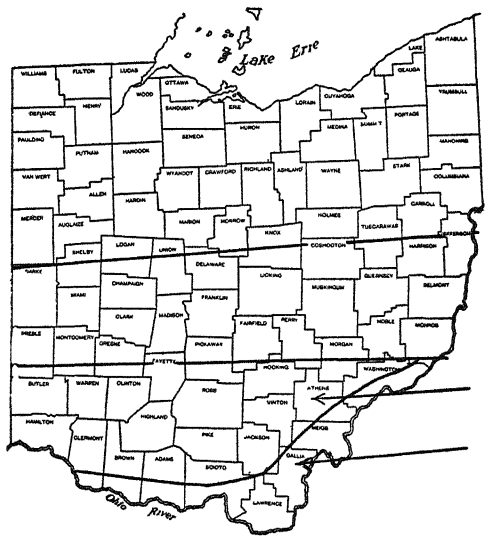
Proprietary remedies.—Many such proprietary remedies of real merit are on the market and the list is increasing rapidly. In this publication some are mentioned but, in practically every instance, these are ones which have been in use for years. The fact that many are omitted does not mean that they are undependable or inefficient, but simply that they may not have been fully tested by this Station or that space prevents our mentioning all of them.

Location.—Geographical location in relation to the distribution of pests must be considered in formulating a spraying program. In general, scab is the most serious disease thruout the State and in the northern part the only serious one to control, while blotch and bitter rot must be considered in the southern part. Moreover, these

southern diseases require, for the most part, different treatments both as to time of application and materials.

Degree of susceptibility.—If possible, the program should be adjusted according to resistance and susceptibility of varieties. For scab control on apples special attention should be given to the susceptible varieties; frequently labor and materials can be saved on the more resistant ones, especially in the summer applications. It is often possible to dilute the fungicide to half the standard strength, or to use a mild spray such as the dry-mix or dust, and by so doing eliminate most of the foliage and fruit injury.

Table 1 indicates the susceptibility of varieties of apples.



Region 1.—Scab serious, black rot moderate.

Region 2.—Scab serious, blotch mild to moderate, black rot moderate.

Region 3.—Scab serious, blotch moderate to serious, black rot moderate.

Region 4.—Scab, blotch, and bitter rot serious; Brooks spot and black rot moderate.

FIG. 1.—Division lines of disease distribution

GENERAL SUGGESTIONS CONCERNING SPRAYING

Aside from the selection of the material to be used and the time of its application, a few principles should be borne in mind in spraying any fruit.

Spraying procedure.—Where a single tree or a few trees are to be sprayed, a quiet day should be selected for the work. Spraying of large trees should commence from beneath the branches, directing the spray upward and outward at all angles, and end from the outside. Selecting a point in the tree, the operator gradually works around, spraying systematically and thoroly as he goes until the

starting point is reached. The practice of spraying here and there over the tree is almost certain to leave uncovered areas. In acreage operations it is best to spray with the wind and when the wind changes to the opposite direction to return and spray the other side of the trees. Here also it is well to follow a definite system; for example, always begin at a definite point and gradually work around until about ⅗ of the tree is covered. In spraying large trees there is some advantage in having two men work together, one riding the sprayer and covering the upper branches while the other, on the ground, covers the lower branches. On small or medium sized trees one man per tree is likely to do better work and waste less material.

TABLE 1.—DEGREE OF SUSCEPTIBILITY

Variety	Scab	Blotch	Bitter rot	Blight	Spray injury on fruit or foliage
Arkansas Black	very	moderately	moderately	slightly	.....
Red Astrachan	very	not	moderately	slightly	.....
Baldwin*	slightly	slightly	slightly	slightly	slightly
Banana	moderately	slightly	slightly	very	.....
Belmont	very	slightly	slightly	moderately	.....
Ben Davis	very	very	very	slightly	very
Delicious	very	slightly	slightly	not	slightly
Early Harvest	very	very	.....	very	slightly
Ensee	moderately	moderately	slightly	moderately	very
Gano	very	very	very	slightly	very
Golden Delicious*	not	slightly	.....	.....	very
Gravenstein	very	very	very	moderately	slightly
Grimes Golden*	very slightly	slightly	moderately	moderately	moderately
Hubbardston	slightly	very	moderately	slightly	.....
Jonathan*†	slightly	slightly	moderately	very	moderately
King David†	slightly	slightly	very	moderately	slightly
Maiden Blush†	moderately	moderately	slightly	moderately	slightly
McIntosh	very	very	very	moderately	slightly
Northern Spy	moderately	moderately	moderately	moderately	moderately
N. W. Greening	moderately	very	moderately	moderately	moderately
Oldenburg*	slightly	very	moderately	very	slightly
Senator	very	moderately	moderately	moderately	slightly
R. I. Greening	moderately	slightly	moderately	moderately	slightly
Rome (Red Rome, Gallia Beauty)	very	slightly	slightly	moderately	slightly
Stark	moderately	very	moderately	moderately	slightly
Stayman	moderately	slightly	slightly	moderately	slightly
Summer Rambo	very	very	.....	moderately	slightly
Wagener	moderately	very	moderately	very	slightly
Wealthy	moderately	slightly	moderately	very	slightly
Wolf River*	not	not	very	slightly	slightly
Yellow Transparent	moderately	not	very	very	moderately
York Imperial*	moderately	not	very	moderately	moderately

*Very dilute or mild sprays may be used on these varieties for scab control.
†Very susceptible to aphis attack.

Quantities of spray.—There is always considerable waste in spraying and when the inexperienced operator finds the material dripping from the tree he is likely to pass to the next without being sure that every part of the tree he is spraying is covered. It is difficult to state just how much liquid to use in spraying a tree of any given size. Generally speaking, however, trees 15 feet high and having an equal spread of branches require from 3 to 5 gallons of spray; trees 20 feet high, 8 to 12 gallons; trees 25 to 35 feet, 15

to 20 gallons. Trees require more liquid to cover them when in foliage than when dormant since some spray is lost thru interference in reaching the inner, more protected, parts. One of the common mistakes, particularly in spraying large trees, is to spray the outer shell only and leave the inner branches practically untouched.

Temperature during spraying.—Spraying should never be done during freezing weather. In the first place much difficulty will be experienced with the equipment under such conditions and in the second either the efficiency of the application may be impaired or, in the case of oils, positive injury to the tree may result. During summer operations, particularly if the sun is very bright, excessive burning may accompany temperatures above 80° or 85°, particularly if the humidity is high. It is the practice in many commercial orchards to stop the sprayers when the thermometer reaches 85°. In some cases we have seen severe injury even in delayed dormant spraying with lime-sulphur when the thermometer stood at 70° and the sun was bright.

The use of spray guns.—Spray-gun injury is very common, particularly when inexperienced men are doing the work. The amateur imagines the hard driving spray is the best. This is not the case. The drive or solid-stream spray should be used only to reach the tops of tall trees and at all other times the fine, mist, fan spray should be employed and the operator should keep at a distance from the tree. It is a good plan to commence at the top of the tree and work downward, gradually adjusting the gun to produce a mist-like spray. Driving the spray may burn the foliage and russet and burn the fruit. Occasionally the crop is almost ruined by the improper use of the spray gun, which in the hands of a skilled workman is an efficient piece of apparatus. Spray guns under no circumstances should be used with pressure under 200 pounds, and 250 to 300 is better. If the pump is not capable of supporting a spray gun at this pressure, then disk nozzles and spray rods should be substituted for it. One should not attempt to use a spray gun on a hand pump.

SPRAY MATERIALS FOR APPLES

Oil spray.—Within recent years the use of oils for spraying has greatly increased, particularly in the dormant period. In Ohio this has been due in large part to the advent of the European red mite, a pest which dormant sprays of lime-sulphur will not control, and in part to the failure of the sulphur sprays to control San Jose scale in some of the south central states. In Ohio, however, lime-sulphur still may be considered an effective control for San Jose scale.

In general, oils are preferable for spraying old, neglected, rough-barked trees because of their greater spreading power which is of distinct value causing the oils to enter crevices and reach scale insects in these protected situations. Moreover, oils are effective against the maple terrapin scale, which is a pest of peaches in some sections, and probably they are of value in destroying the eggs of some species of leaf hoppers affecting apple.

The oils are inferior to lime-sulphur to the extent that they do not possess fungicidal value and thus cannot be utilized as dormant applications for the control of peach leaf-curl or as delayed dormant sprays as an aid in controlling apple scab and perhaps other diseases. However, those oils which have been made miscible in water by the addition of soap combine readily with bordeaux mixture, and those which have been made miscible by the addition of some colloidol substance, such as Fuller's earth, calcium caseinate, etc. tolerate the addition of lime-sulphur. In either case the fungicidal effect is obtained.

The oils are used almost exclusively as dormant applications and do not lend themselves readily to delayed dormant spraying, because of possible injury. Altho some oils are safer than others for delayed dormant use, yet the margin of both time and safety is so small in the delayed dormant period that the use of oils at that time seems to be a questionable practice.

Soluble or miscible oils.—Several such oils are manufactured and sold by commercial firms. The formula by which they are made is usually a trade secret. Their properties, as a rule, are as stated in the above discussion. These oils should be used at the strengths recommended by the manufacturers.

Lubricating oil emulsions.—These emulsions can be made at home or can be purchased from companies who manufacture them according to directions issued by the U. S. Department of Agriculture. The following formula is recommended:

Lubricating oil (see specifications)	2 gal.
Water "soft"	3 qt.
Potash fish-oil soap	2 lb.

These three materials are mixed in a vessel and are heated till they start to boil. The vessel is then taken from the fire and the mixture pumped two or three times thru a nozzle with a medium fine opening. A bucket pump, the pump on a power sprayer, or any intermediate type of pump will do this work satisfactorily. The stock emulsion so formed is semi-permanent but may be broken down by freezing.

Adding 3 gallons of the stock emulsion to 100 gallons of water will give a spray containing 2 percent of oil. If a 3 percent oil spray is desired use 4½ gallons of the emulsion to 100 gallons of water.

If "hard" water is used for diluting the spray, it may be "softened" by making it into a weak (1-1-200) bordeaux mixture. This will permit satisfactory dilution of the emulsion.

A lubricating oil for making the emulsion at home should have specifications falling within the following limits.

Viscosity—from 90 to 250 seconds at 100° F. (Saybolt)
Volatility—less than 2 percent
Specific gravity—from 0.88 to 0.91 at 68° F.

Oils having either a parrafin or an asphalt base may be used. Any oil company can furnish oils falling within these limits.

From 1 to 2 gallons of the stock emulsion as a spreader can be used per 200-gallon tank of spray, with any strength bordeaux mixture, with nicotine, or with arsenate of lead, but not with lime-sulphur.

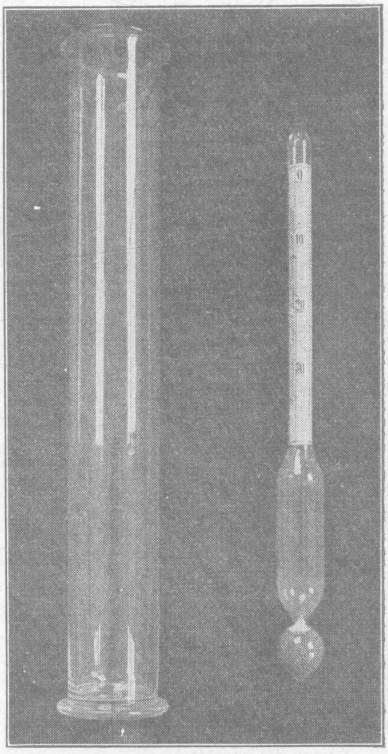


Fig. 2.—Baumé hydrometer

Liquid lime-sulphur.—Lime-sulphur is now prepared and sold by a number of chemical companies and practically all brands are of equal value providing the Baumé reading is 33°. The Baumé test is made with a hydrometer, an inexpensive instrument that every grower should possess. A lime-sulphur having a 33° Baumé reading contains 2.7 pounds of sulphur to a gallon of the concentrate. The sulphur is mostly in the form of penta-sulphides which are most effective in killing, and cause the least injury to foliage. The minimum strengths to be used for San Jose scale and the strengths for summer spraying of apples are given in Table 2. For dormant spraying the mixture can be used somewhat stronger than recommended in the table, without ill

effects, but the expense is considerably increased by doing so and no practical advantage is gained. The summer strengths should in no case be increased beyond the figures given in the table.

TABLE 2.—DILUTIONS FOR DORMANT AND SUMMER SPRAYING WITH LIME-SULPHUR MIXTURES

Reading on hydrometer	Number of gallons of water to one gallon of lime-sulphur solution	
	For San Jose scale, winter use	For summer spraying of apples
Degrees Baumé		
35	8.00	45.0
34	7.50	43.0
33	7.00	40.0
32	6.50	37.5
31	6.00	36.0
30	5.50	34.0
29	5.25	33.0
28	5.00	31.0
27	5.00	29.5
26	5.00	28.0
25	4.50	26.0
24	4.25	24.0
23	4.00	23.0
22	3.50	21.0
21	3.25	20.0
20	3.00	18.0
19	2.75	17.0
18	2.50	16.0
17	2.50	15.0
16	2.00	14.0
15	2.00	13.0
14	1.75	12.0

Dry lime-sulphur.—For greater convenience in handling, shipping, and storing, manufacturers have devised powdered forms of lime-sulphur. Powdered lime-sulphur contains the same ingredients as liquid lime-sulphur, and in addition a stabilizer making its manufacture possible. Adverse results following the use of dry lime-sulphur are reported from some of the states, but under Ohio conditions we have obtained excellent control of San Jose scale where this material was used as a delayed dormant application at the rate of 15 pounds to 50 gallons of water, and of scab where used for pre-blossom sprays at the rate of 3½ to 4 pounds.

Since dry lime-sulphur is a newer material and less thoroly tested than the concentrated liquid, and for this reason alone, we do not have quite the confidence in it that we have in the liquid form. On the other hand, our results covering a period of years have been so uniformly satisfactory that we do not feel justified in doing otherwise than concurring in its use.

Soluble sulphur.—Soluble sulphur, which is a compound of sodium and sulphur or of potassium and sulphur, possesses about the same merits for dormant spraying as the true lime-sulphur powder. It is used at a strength of 12½ pounds to 50 gallons of

water. It is exceedingly dangerous to the leaves when combined with arsenicals for a foliage spray and should never be so used.

Bordeaux mixture.—The old standard bordeaux mixtures are prepared with equal weights of copper sulphate and stone (lump) lime in 50 gallons of water. Since stone lime is rarely available, it is necessary to substitute hydrated lime, in which case approximately one and one-half times as much lime should be used and the formula read 4-6-50. In all recommendations included in this bulletin a good fresh hydrated lime will be used.

A good method for the preparation of bordeaux mixture is as follows: Dissolve the required amount of copper sulphate in the ratio of 1 pound to 1 gallon of water, suspending the copper-sulphate crystals in a sack near the top of the water. The warmer the water the more rapidly the crystals will dissolve, but they will dissolve in moderately cold water in a few hours.

TABLE 3.—CONCENTRATED COMMERCIAL MIXTURE IN BORDEAUX MIXTURES OF GIVEN FORMULAS*

Metallic copper declared on label	Pounds of concentrated mixture necessary to add to 50			
	2-4-50	3-5-50	4-6-50	5-8-50
Percent				
4	12.75	19.13	25.50	31.8
6	8.47	12.70	16.97	21.2
8	6.37	9.55	12.75	15.9
10	5.09	7.63	10.17	12.7
12	4.24	6.35	8.47	10.6
14	3.64	5.45	7.27	9.1
16	3.17	4.76	6.35	7.9
18	2.83	4.24	5.66	7.1
20	2.55	3.81	5.09	6.4
22	2.31	3.47	4.63	5.8

*Prepared by Department of Chemistry, Ohio Agricultural Experiment Station.

The stock hydrated lime is prepared by making a paste of known strength which can be washed into the tank thru a screen. If a 4-6-50 mixture is desired and a 100-gallon spray tank available, 8 gallons of the stock copper solution is poured into the tank, which is then filled two-thirds full with water. The lime paste is then washed into the tank as described above, and the tank filled with water. If a good grade of fresh hydrated lime is available it may be sifted directly into the tank containing the dilute copper solution. In either case the agitator should be running while mixing.

If the grower does not wish to prepare his own bordeaux, he may purchase dry or paste commercial products, which are effective and safe when used according to the copper equivalents as given in Table 3.

Bordeaux mixture is not recommended for use in apple orchards in the northern half of Ohio. While it will control scab it is likely to cause much spray injury, especially during cool, damp weather. Bordeaux is recommended for use in the southern part of the State, where blotch and bitter rot are serious. It should be used only when these are severe and only at the times for their best control. See Table 4, for apple spraying.

Arsenate of lead.—Arsenate of lead is the most satisfactory poison for spraying fruit. When it was first placed on the market it was sold in paste form, but of late years a powdered form has been produced which is so superior to the paste in many respects that it is now used almost exclusively. The process of manufacture has become so standardized that the product of any reputable firm is dependable. It may be used as a liquid spray in water or in combination with lime-sulphur or bordeaux or in a triple-purpose spray with nicotine sulphate added to either of the above combinations. It should never be used in combination with Niagara Soluble Sulfur compound.

As a dust application it may be used in combination with sulphur, lime, gypsum, or flour.

SPREADERS

In spraying certain fruits, particularly grapes, and in some cases cherries, it is desirable to add some material to the liquid which will improve its spreading or covering properties. Moreover some materials, as for example, nicotine sulphate, are rendered more effective against plant lice and other pests by adding a spreader. A spreader is also sometimes desirable in the last codling-moth spray, especially of early apples. In this spray the spreader is added, not so much from the standpoint of contributing to the effectiveness of the treatment, as to deposit the white residues of the dried spray evenly over the fruit. Otherwise the spray collects in droplets. Since the early varieties are picked before rains have a chance to wash off the spray deposits, they may spray-mark the fruit and thus injure its sale. Recent findings, however, indicate that the addition of a spreader may detract from the effectiveness of the poison in codling-worm control.

The spreaders available are soaps, calcium caseinate, and oil emulsions.

Of the soaps, the potash fish-oil soaps are most desirable. They ordinarily are used at the rate of 2 pounds to 50 gallons of spraying liquid. In the absence of these, ordinary laundry soaps

may be used. Several commercial brands of the calcium caseinates are available. It is customary to add about ½ pound to 50 gallons of spray.

In using oils as spreaders, considerable discretion must be exercised. The soap emulsions can be used with bordeaux sprays but should never be used with lime-sulphur sprays. With the latter some oils may be used in which the emulsifying agent is not a soap. In no case should more than 1 gallon of any oil be added to 100 gallons of a spray containing either lime-sulphur or bordeaux mixture. Since the addition of either a miscible oil or an oil emulsion to a summer spray, is a comparatively new development, we repeat our caution against the indiscriminate adoption of the practice.

ORCHARD DUSTING

The application of fungicides and insecticides in the form of dust has received an immense amount of attention from experimenters during the last decade. Commercial companies interested in marketing dust materials and machinery have gone to great expense in attempting to demonstrate the possibility of completely substituting dusting for spraying. As a result excellent dusting machines for operation by hand and by power are available and they greatly surpass spraying machines in the rapidity with which materials can be applied. Many brands of ready-mixed fungicides and insecticides especially prepared for use in such machines are now on the market. There are also on the market self-mixing power dusters by the use of which the grower can easily prepare his own mixtures, in which case he can choose combinations of materials best suited for his needs.

However, with all this progress, we have not yet a dust which can take the place of the dormant sprays for killing scale insects. Some success has been attained by the use of dusts for the killing of biting insects of fruit, such as codling worm and curculio. Many sucking insects also yield quite readily to control by contact dusts, such as nicotine, cyanide, and others. Dusts have been only partially effective in the control of fruit diseases. In 1925, a dry season in which apple scab was easy to control, the 300-mesh ground sulphur gave excellent results while in 1924, a season favorable for scab development, it did not give commercial control. Results of our experiments over the same period show that, where scab was held in check by pre-blossom spraying, dusts were effective when used for all subsequent applications. These tests also demonstrated that the more finely ground sulphur, such as 300 to 350 mesh, when used without an alkaline filler or spreader was most effective.

The use of dust for summer application is of value in that very little injury of foliage or fruit will result and if the grower can make the substitution he may expect fruit of better finish than from summer spraying. Whether dusts can be substituted for these applications, the grower, if he has controlled scab, will be able to determine by the time he needs to make the substitution.

In general, the dusting recommendations are as follows:

(1) Use best dust obtainable, 300-mesh, or finer-ground, sulphur.
(2) In localities or orchards where scab and other pests have been easy to combat, dusts may be substituted thruout.
(3) When scab has been held in check by pre-blossom and calyx sprays, dusts may be substituted for the remainder of the season.
(4) In orchards where scab is a serious factor annually, dusts, when used thruout the season, may be expected to give commercial control three years out of five.
(5) The above general suggestion may be followed in southern Ohio where blotch and bitter rot are factors, except that a good grade of copper-lime dust be substituted for the sulphur dusts for their control.

The application of dust should be made when the air is calm, preferably in early morning or late afternoon. When dusts are used entirely for disease control the application should be more frequent than spraying, especially in the pre-blossom period. It is a common practice to dust weekly on alternate sides of trees.

In general, the use of both fungicidal and insecticidal dusts is more expensive than the use of liquids.

SPRAYING PROGRAM FOR APPLE ORCHARDS

Dormant or delayed dormant spray.—This important spray should be given all orchard trees. An oil is used if European red mite be present and the application is made while the trees are in the dormant period. Several oils are available for this spray. The following are representative examples with the formulas:

Scalecide	3	gal.
Water	50	gal.
Sunoco	2½	gal.
Water	50	gal.
Free-mulsion	1½	gal.
Water	50	gal.
Engine-oil emulsion	2¼	gal.
Water	50	gal.

If European red mite is not present, it seems preferable to use a lime-sulphur or soluble-sulphur compound as a delayed dormant spray, for by so doing it is possible that considerable benefit by way of scab control will result. One of the following formulas may be used:

Liquid lime-sulphur	6¼	gal.
Water	50	gal.
Dry lime-sulphur	15	lb.
Water	50	gal.
Soluble-sulphur compound	12½	lb.
Water	50	gal.

When aphids are abundant add nicotine sulphate at the rate of ½ pint to each 50 gallons of spray and if canker worms or bud moth are troublesome add arsenate of lead to any one of the formulas, except the soluble-sulphur compound, at the rate of 1¼ pounds to 50 gallons. Lead should not be used in the combination because excessive burning will result.

Pre-blossom scab sprays.—Spraying from the time of the delayed dormant until full bloom is primarily for the control of scab and black rot. This is the most important period for disease control. In previous recommendations the times of application were pre-pink and pink. In other words the sprays were timed according to the stage of growth. We have determined more recently that the pre-blossom sprays should be timed according to the development of the scab fungus, since primary scab infection takes place shortly after the spores are discharged. While it is difficult for the grower to determine this exact time, he probably can get the information from the spray service if he is located in a fruit district. If he is not able to get this information, he should time the applications ahead of rains and keep the foliage well covered thruout the period to insure control of primary infection.

All spraying in this period should be timed to just precede rains. Scab spores shoot and infect during and just following rain.

Lime-sulphur and lead arsenate are used according to the following formula:

Lime-sulphur	1¼	gal.
Water	50	gal.
or		
Dry lime-sulphur	3½	lb.
Water	50	gal.

If red bug is serious, nicotine sulphate can be added to either of the above sprays at the rate of ½ pint per 50 gallons.

Calyx-cup spray.—Freedom from worms in apples depends upon this spray.

Lime-sulphur in some form and arsenate of lead are the principal ingredients and should be used according to the following formula:

Lime-sulphur	1 gal.
Arsenate of lead	1¼ lb.
Water	50 gal.

or

If season is not favorable for scab development

Dry-mix	12 lb.
Arsenate of lead	1¼ lb.
Water	50 gal.

or

85-15 sulphur dust

If the green apple aphis is numerous or if the apple red bug is known to be present in the orchard, nicotine sulphate should be added at the rate of ½ pint to each 50 gallons of the above formula. Spray just after the petals fall and make the application with all possible thoroness, using good pressure (not under 200 pounds) and an abundance of liquid. The tree will be dripping profusely when it is finished.

The 2- to 3-week spray.—This application should never be omitted in Ohio. In the southern part of the State where blotch is serious a special spray of 2-4-50 bordeaux is necessary. When blotch infections are mild or do not exist use the same sprays as recommended for the calyx-cup spray and add additional lime to summer sprays.

Special blotch spray.—Where blotch is serious a special spray of 2-4-50 bordeaux should be applied about 4 weeks after petal fall. In some cases lime-sulphur, 1-40, can be depended upon to control blotch thruout the season (Ballou).

Second brood codling moth spray.—The exact time for this application should be determined each year. Usually the proper time for this spray is about 9 to 10 weeks after petal fall, or from July 1 to 25 in southern Ohio, July 20 to August 1 in northern Ohio. In the southern part of the State it may be necessary to substitute a 2-4-50 bordeaux for the lime-sulphur to control blotch, bitter rot, and Brooks spot.

As discussed under the subject of spreaders, it is sometimes advisable, particularly in the case of spraying apples, to add some material to this spray to enable it to spread evenly over the surface of the fruit. When the spreader is omitted the spray material col-

lects in drops and the dried deposit may disfigure the fruit. Otherwise use same recommendations as given for the calyx-cup sprays.

Special bitter-rot spray.—This spray is only needed occasionally in region 4 of the State, but it should be applied immediatey when an outbreak of bitter rot is threatened. The spray formula is 2-4-50 bordeaux.

TABLE 4.—SPRAYING PROGRAM FOR APPLE ORCHARDS
(For young, non-bearing trees see page 18)

Time of application	Materials	To control	Suggestions
Dormant or delayed dormant	(Oil dormant only, see note) **Lime-sulphur** 6 ¼ gal. (or dry lime-sulphur 15 lb.) Nicotine sulphate ½ pt. Water 50 gal.	Scales Aphids European red mite Scab Various plant bugs	When red mite is serious use oil, but during dormant period only. Under other conditions the use of lime-sulphur either with or without nicotine-sulphate is preferred and the application is most effective during the delayed dormant period.
Pre-blossom sprays When possible spray should be timed according to scab-spore shooting. When this is impossible, keep trees covered.	**Lime-sulphur** 1¾ gal. (or dry lime-sulphur 3½ lb.) Arsenate of lead 1 lb. Water 50 gal.	**Scab** Curculio Canker worm Bud moth Black rot (Frog eye)	This is the most important spray for the control of scab. Arsenate of lead may be omitted if canker worm or bud moths are not serious. In seasons unfavorable for scab, 300-mesh sulphur dust may be substituted for lime-sulphur.
Calyx-cup spray Apply just after petals fall.	**Lime-sulphur** 1 gal. (or dry lime-sulphur 3 lb.) Arsenate of lead 1¼ lb. Water 50 gal. or 85-15 300-mesh sulphur dust	**Codling moth** Scab Aphids Red bug Brooks spot	This spray should never be omitted. If aphids or red bugs are serious ½ pint of nicotine sulphate should be added.
2-to 3-week spray In northern Ohio spray 3 weeks after calyx cup. In southern Ohio 2 weeks after if blotch is present.	**Lime-sulphur** 1 gal. (or dry lime-sulphur 3 lb.) Arsenate of lead 1 lb. Water 50 gal. or 90-10 300-mesh sulphur dust	**Codling moth** Scab Brooks spot Blotch	If scab is not serious, dry-mix, 12 lb. to 50 gal. or a 90-10 300-mesh sulphur may be substituted for the lime-sulphur.
Special blotch spray	Same as 2-to 3-week spray	**Blotch** Brooks spot	If blotch is serious, 2-4-50 bordeaux should be substituted for lime-sulphur. Copper lime dusts may also be substituted if blotch is not too serious.
Second brood codling moth spray Exact time to be determined each year.	Same as calyx-cup spray	**Codling moth** Scab Blotch } In Bitter rot } southern Ohio	Bordeaux, 2-4-50, should be substituted if bitter rot is present.

NOTE Oil sprays for dormant

Scalecide	1 gal., water 15 gal.	Engine-oil emulsion	4½ gal., water 100 gal.
Sunoco	1 gal., water 20 gal.	Free-mulsion	4½ gal., water 100 gal.

SPRAYING PROGRAM FOR YOUNG ORCHARDS NOT BEARING

Young orchards of all fruits not bearing should receive the dormant spray, and at least one foliage spray soon after the leaves are fully expanded.

Dormant spray formula:

Lime-sulphur	6¼ gal.
Water	50 gal.

Foliage spray formula:

Lime-sulphur	1¼ gal.
Water	50 gal.

About midsummer it is sometimes necessary to spray with arsenate of lead 1¼ pounds to 50 gallons of water for the red humped apple worm and the apple datana.

SPRAYING PROGRAM FOR PEAR AND QUINCE

Dormant or delayed dormant.—On favorable days in late fall, occasionally in winter, and again in spring, the pear psylla, too stiff from cold to move about, may be found hanging from twigs and branches. On such days practically all these insects can be killed by spraying the tree thoroly from all sides with a miscible oil. This spray will likewise serve to control scale insects. The spraying should be complete so the psyllids may not migrate from the unsprayed part to that which was treated. Use winter strength of the oil.

In some states the delayed dormant spray is timed to kill eggs of psylla. The formula recommended for the delayed dormant spray is—

Lime-sulphur	6¼ gal.
(or dry lime-sulphur	15 lb.)
Water	50 gal.

Pre-blossom spray.—This spray is necessary only in orchards when scab is prevalent and only on susceptible varieties. The spray is—

Lime-sulphur	1¼ gal.
(or dry lime-sulphur	3½ lb.)
Water	50 gal.

Petal-fall spray.—This spray is to control codling moth, psylla, and scab. The formula is—

Lime-sulphur	1 gal.
(or dry lime-sulphur	2½ lb.)
Arsenate of lead	1¼ lb.
Hydrated lime	1 lb.
Water	50 gal.

Special psylla spray.—This spray is made with lime-sulphur concentrated solution, 1 gallon to 50 of water, plus ½ pint nicotine sulphate, when honey-dew spots around the young larvae are first seen on the leaves. This spray should be directed upward against the under side of the leaves. In case this appearance coincides in time with Spray No. 3 for codling worm, arsenate of lead is added and the spray applied from both above and below. In case of high temperature or other condition which is likely to cause burning by lime-sulphur concentrated solution at summer strength, use the dry-mix instead. Pear foliage in summer is quite sensitive to lime-sulphur injury.

TABLE 5.—SPRAYING PROGRAM FOR PEAR AND QUINCE

Time of application	Materials	Pests	Suggestions
Dormant	Oil	Scale European red mite	
Delayed dormant When leaf buds show green before leaves appear	Lime-sulphur 6¼ gal. (or dry lime-sulphur 15. lb.) Water 50 gal.	Scab Psylla	
Pre-blossom spray When cluster buds show color before blossoms open	Lime-sulphur 1¼ gal. (or dry lime-sulphur 3⅛ lb.) Water 50 gal.	Scab Leaf-spot	This spray may be omitted where disease is not prevalent
Petal-fall spray*	Lime-sulphur 1 gal. (or dry lime-sulphur 3⅛ lb.) Arsenate of lead 1¼ lb. Water 50 gal. Hydrated lime 1 lb.	Codling moth Scab Pear slug Sooty fungus Leaf-spot	
9 to 10 weeks after petal-fall*	Dry-mix 12 lb. Arsenate of lead 1 lb. Water 50 gal. or Dritomic sulphur 2½ lb. Hydrated lime 1 lb. Arsenate of lead 1 lb. Water 50 gal. or 90-10-10 sulphur dust	Codling moth Scab Sooty fungus Leaf-spot Psylla	If Psylla is present add ½ pint nicotine sulphate per 50 gallons

*Pear foliage is severely burned by lime-sulphur solution at summer strength if the temperature is high, and under such condition should be replaced by dry-mix or other mild sprays.

The 9- to 10-week spray.—At the time of year for this spray, pear foliage is quite susceptible to spray burn and unless psylla is serious lime-sulphur should not be used. The following formula is recommended:

Dry-mix	12	lb.
Arsenate of lead	1	lb.
Water	50	gal.
or		
Dritomic sulphur	2½	lb.
Arsenate of lead	1	lb.
Hydrated lime	1	lb.
Water	50	gal.
or		
80-10-10 sulphur dust		

SPRAY MATERIALS FOR STONE FRUITS

The foliage of stone-fruit trees is usually more tender and susceptible to spray injury than that of pomaceous trees; consequently, different sprays are necessary. The old standard substitute for this type of fruit, self-boiled lime-sulphur, has been largely replaced by the commercial dry-mix sulphur-lime. The latter is composed of sulphur and lime mixed dry with calcium caseinate or glue. This is a mild spray as compared with liquid or dry lime-sulphur both of which are very caustic. This mixture of sulphur and lime-caseinate is manufactured commercially by practically all firms making spray materials and is sold under a variety of names such as New Jersey dry-mix, Peach-mix, dry-mix, and sulphur-lime dry-mix. The grower can prepare his own mixture by simply mixing a fine grade of sulphur, 6 pounds; hydrated lime, 3 pounds; and Kayso, 2 ounces. Using these proportions, the season's supply can be mixed before spraying operations begin. The mixture is used at the rate of 9 to 10 pounds to 50 gallons of water.

Another peach spray of a similar nature is dritomic sulphur, which is equally as effective as the dry-mix. The company's recommendation is 2½ pounds per 50 gallons of water.

Sulphur dusts have been found effective for summer application on peach and other stone fruits. These dusts can be procured ready mixed commercially, or the grower can mix them by the use of the self-mixing duster. The proportion recommended for peaches is 80 pounds of sulphur, 10 pounds of hydrated lime, and 10 pounds of powdered arsenate of lead. Dusts rarely cause injury to foliage and are very effective in the control of brown rot, the most serious stone fruit disease.

SPRAYING PROGRAM FOR STONE FRUITS

Dormant spray.—The most satisfactory time for the control of leaf-curl of peaches is in the autumn just after the leaves fall. The application may be made any time during the fall and early spring

on days when the temperature is above 50° F, but it must be made before the buds swell. After the buds swell and open slightly it is too late to control leaf-curl. While lime-sulphur is the most effective control spray for curl, bordeaux-oil may be used if mites are present and the application should be made in early spring. The formula:

Liquid lime-sulphur	6¼ gal.
(or dry lime-sulphur	15 lb.)
Water	50 gal.
or	
Bordeaux 4-6-50 and oil	

Husk-fall spray.—This is a general spray for all stone fruits and may be expected to control brown rot and scab on peaches, to check leaf-spot on cherries, and to control curculio. The general dry-mix or dritomic sulphur should be used as a spray, or the 80-10-10 sulphur-lime-arsenate as a dust, as follows:

Dry-mix	10 lb.
Arsenate of lead	1¼ lb.
Water	50 gal.
or	
Dritomic sulphur	2½ lb.
Water	50 gal.
or	
80-10-10 dust	

The 2- to 3-week spray.—The 2- or 3-week application may be omitted under certain conditions, such as in a season unfavorable for disease and insect development or, if pests have been controlled by preceding sprays. In general, however, it should be a standard application. On cherries it should come later, or just when the fruit begins to color, and it can be expected to check leaf-spot. We do not recommend sulphur dusts for the control of leaf-spot except in dry seasons. The formula is—

Dry-mix	10 lb.
Arsenate of lead	1¼ lb.
Water	50 gal.
or	
Dritomic sulphur	2½ lb.
Water	50 gal.
or	
80-10-10 dust	

Pre-harvest spray.—This spray is applied two or three weeks before fruit is picked, and should never be omitted except on cherries. It should not contain arsenates or any other poisons. It is an assurance against late infection or epidemics of brown rot and a protection against the rotting of fruit in packing and shipping. Use materials as recommended in husk-fall spray, except omit poisons.

After-harvest spray for cherry leaf-spot.—This spray should be applied shortly after the fruit is picked. The formula is as follows:

Lime-sulphur	1	gal.
(or dry lime-sulphur	3	lb.)
Arsenate of lead	1	lb.
Water	50	gal.

TABLE 6.—SPRAYING PROGRAM FOR PEACHES AND PLUMS AND CHERRIES

Time of application	Materials	Pests	Suggestions
In fall after leaves drop or before buds begin to swell in spring.	Lime-sulphur 6¼ gal. Water 50 gal. or Oil plus bordeaux 4-4-50	Peach leaf-curl Scale insects European red mite	See note under apple, for proper strength of oil sprays.
After bloom has fallen when husks are shedding.	Dry-mix 9—10 lb. Lead arsenate 1½ lb. Water 50 gal. or Dritomic 2¼ lb. Arsenate of lead 1½ lb. Water 50 gal. or 80-10-10 sulphur dust	Brown rot Curculio Scab Leaf-spot	This spray should never be omitted.
2 to 3 weeks after spray No. 2, or on cherries when fruit begins to color.	Same as No. 2	Brown rot Curculio Scab Leaf-spot	This spray may be omitted, except on sour cherries in seasons unfavorable for brown rot.
Apply 2 to 3 weeks before fruit is picked.	Same as No. 2, except omit lead arsenate or Sulphur dust 80-20	Brown rot	This spray should never be omitted, except on sour cherries.
Just after fruit is harvested, for cherries only.	Lime-sulphur 1 gal. Water 50 gal. Arsenate of lead 1¼ lb.	Leaf-spot Slugs	

GAS TREATMENT FOR PEACH BORER

Paradichlorobenzene was first used for the destruction of the peach borer by E. B. Blakeslee, now of Medina, Ohio, but then employed in the Bureau of Entomology, U. S. Department of Agriculture. The results of his use of this treatment were given to the public in 1919 in Bulletin 796 of the Bureau of Entomology. Important confirmatory work and additional research work have since been done at the New Jersey Agricultural Experiment Station; and in many states peach orchardists have given it extensive trials. The results generally have been satisfactory and the value of this remedy may be considered as successfully proved.